

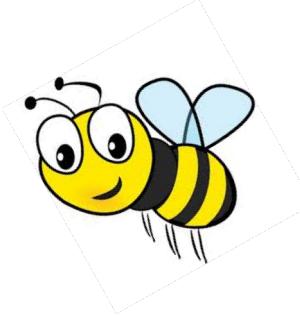


ML2 Honey Bee Images

Group 4

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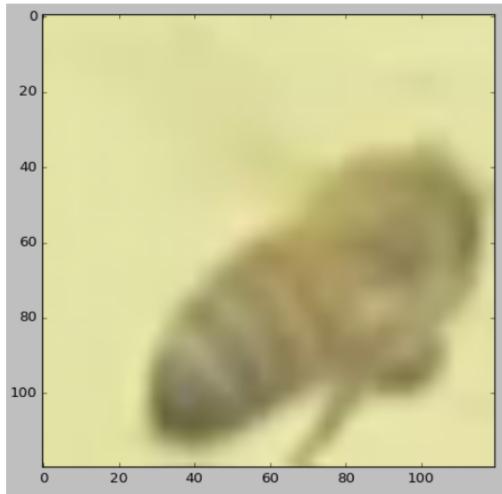
Introduction



- Dataset: The Bee Image Dataset
- columns:
 - file: 5172 images
 - date: 7/2/18 ~ 9/8/18
 - time: 8:20 ~ 21:13
 - location: 8 locations
 - zip code
 - subspecies: 7 subspecies
 - health: Hive health (healthy, few varroa hive beetles, ...)
 - pollen_carrying: true / false
 - caste: worker

Some Examples

- The pictures are extracted from still time-lapse videos
- Then each bee is cropped out to ensure each image has only one bee



Western honey bee
healthy

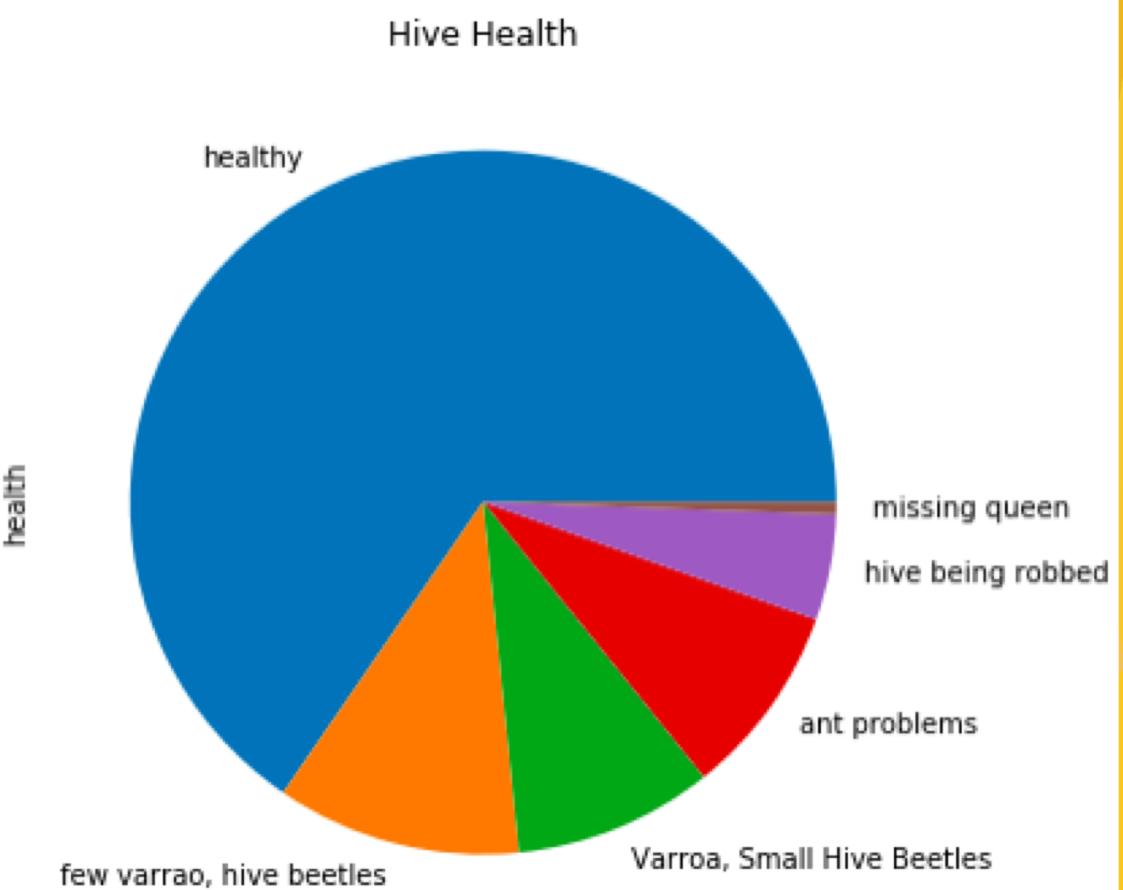
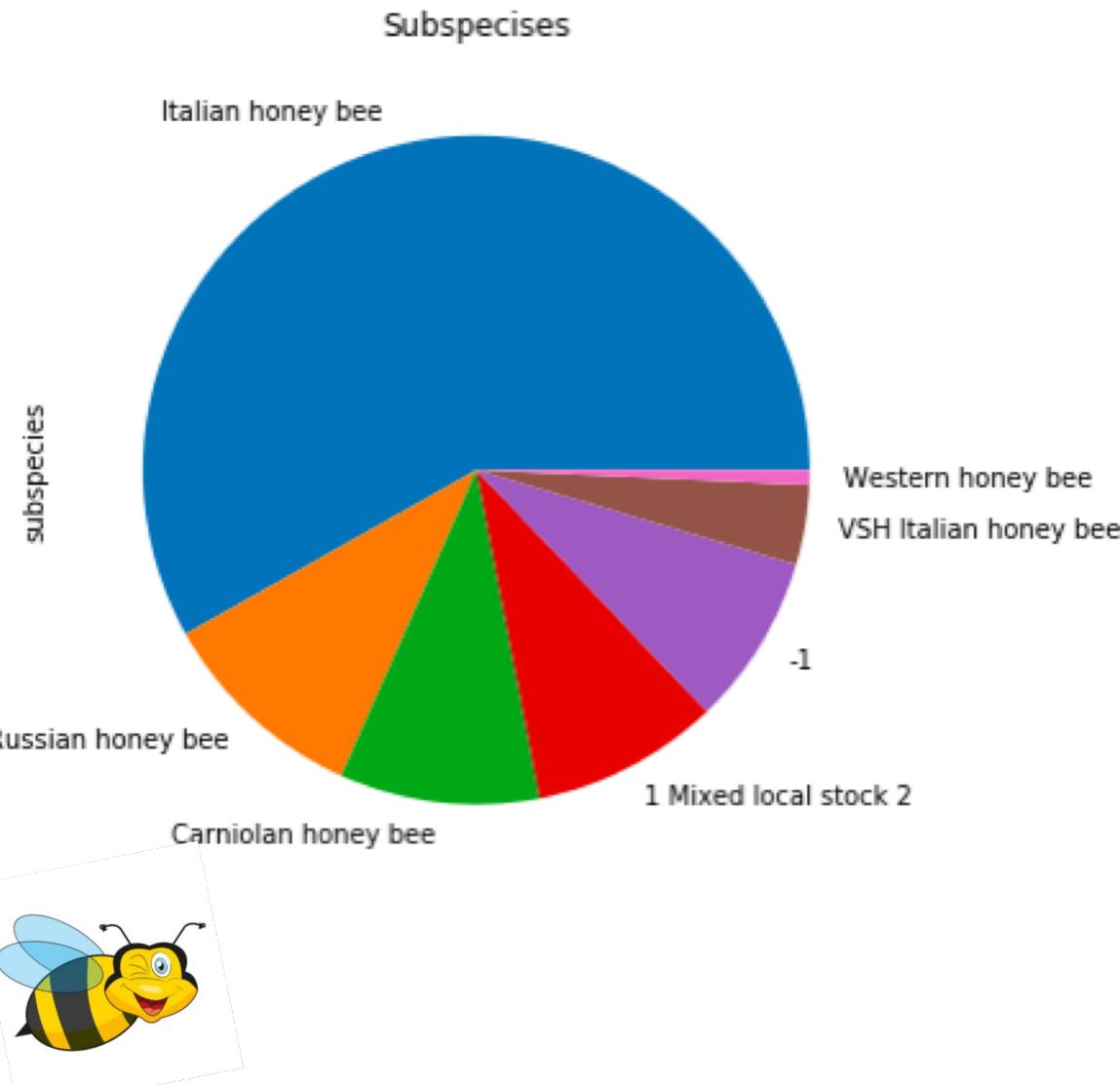


Italian honey bee
few varroa, hive beetles



Italian honey bee
healthy

EDA



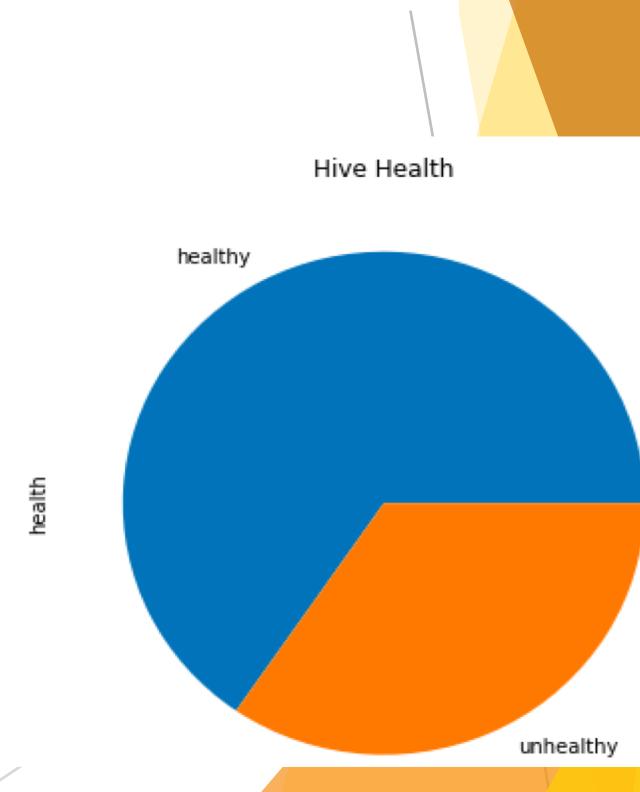


Preprocessing

- Subspecies
 - Convert classes to int.
 - Scale class strings to [0,1]
- Hive Health
 - change all unhealthy circumstances into ‘unhealthy’
- Train test split (70-30)
 - Train set: 3620 images
 - Test set: 1552 images



| | | |
|-----------------------|----|---------|
| 1 Mixed local stock | 2 | class 0 |
| Western honey bee | 1 | class 1 |
| Carniolan honey bee | 2 | class 2 |
| VSH Italian honey bee | 3 | class 3 |
| Italian honey bee | 4 | class 4 |
| Russian honey bee | 5 | class 5 |
| | -1 | class 6 |



Subspecies Classification - Keras



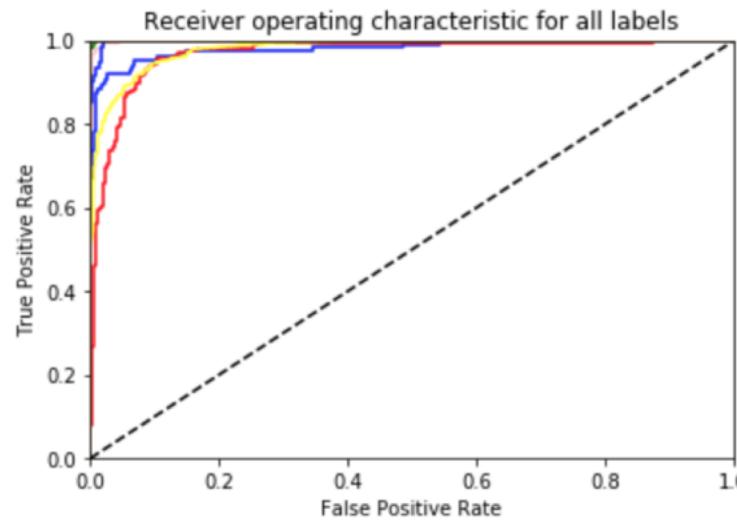
| model43_b | 3 conv total 23 | 0.90 | 0.91 | 0.859 | 3,3,3, 3,3,3, 2,2 | Glorot uniform | Adam | Categorical_CE | softmax | 263 | 47 | 232 |
|---------------|-----------------|------|------|-------|--------------------|----------------|------|-------------------------|---------|-----|----|-----|
| model43_bdr | 4 conv total 23 | 0.92 | 0.93 | 0.88 | 3,3,3, 3,3,3, 2,2 | Glorot uniform | Adam | Categorical_CE | softmax | 314 | 48 | 32 |
| model43_w | 4 conv total 15 | 0.89 | 0.89 | 0.82 | 3,3,3, 3,3,3, 2,2 | Glorot uniform | Adam | weighted_categorical_CE | softmax | 83 | 22 | 32 |
| model43_f | 4 conv total 15 | 0.93 | 0.93 | 0.89 | 3,3,3, 3,3,3, 2,2 | Glorot uniform | Adam | Focal loss | sigmoid | 180 | | |
| model43l_r005 | 4 conv total 15 | 0.86 | 0.86 | 0.77 | 3,3,3, 3,3,3, 2,2, | Glorot uniform | Adam | Categorical_CE | softmax | 185 | | |

Kernel size, activation, optimizer, adding layers

Custom loss function

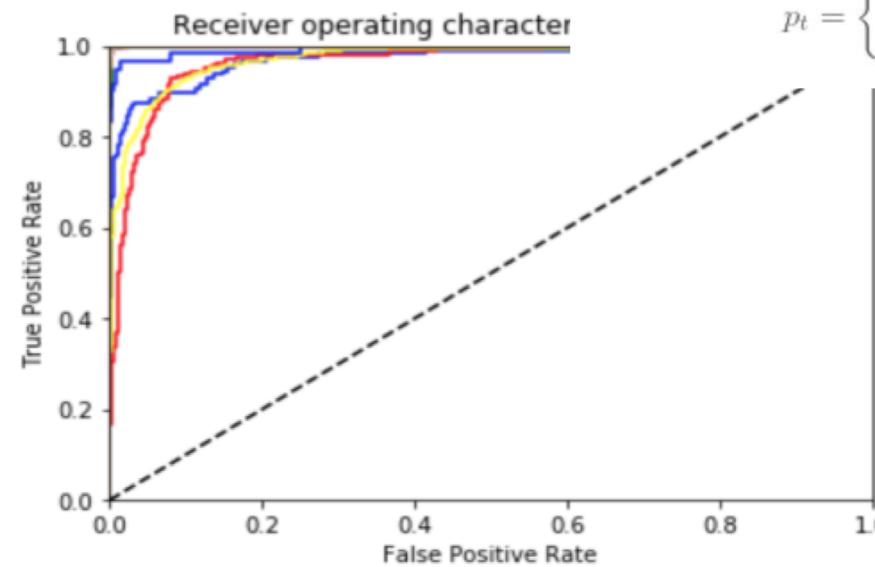
| | | | | | | | | | | | | |
|-----------|-----------------|------|------|-------|--------------------|----------------|------|----------------|---------|-----|----|----|
| model_sg | 2 conv total 8 | 0.97 | 0.91 | 0.86 | 5,5,3,3 | Glorot uniform | Adam | binary_CE | sigmoid | 179 | 50 | 32 |
| models_S | 2 conv total 8 | 0.77 | 0.72 | 0.059 | 5,5,3,3 | Glorot uniform | SGD | Categorical_CE | softmax | 165 | 50 | 32 |
| models_sa | 2 conv total 8 | 0.91 | 0.91 | 0.86 | 5,5,3,3 | Glorot uniform | Adam | Categorical_CE | softmax | 164 | 50 | 32 |
| model45 | 4 conv total 15 | 0.91 | 0.91 | 0.86 | 5,5,3,3, 3,3, 2,2, | Glorot uniform | Adam | Categorical_CE | softmax | 134 | 37 | 32 |
| model43 | 4 conv total 15 | 0.92 | 0.93 | 0.88 | 3,3,3, 3,3,3, 2,2, | Glorot uniform | Adam | Categorical_CE | softmax | 178 | 50 | 32 |
| model43_h | 4 conv total 15 | 0.91 | 0.92 | 0.867 | 3,3,3, 3,3,3, 2,2, | he_normal | Adam | Categorical_CE | softmax | 83 | 27 | 32 |

Model 43



- ROC curve of class -1 (area = 0.98)
- ROC curve of class 1 Mixed local stock 2 (area = 0.97)
- ROC curve of class Carniolan honey bee (area = 1.00)
- ROC curve of class Italian honey bee (area = 0.98)
- ROC curve of class Russian honey bee (area = 1.00)
- ROC curve of class VSH Italian honey bee (area = 1.00)
- ROC curve of class Western honey bee (area = 1.00)

```
show_roc_auc(model43_f)
```



- ROC curve of class -1 (area = 0.97)
- ROC curve of class 1 Mixed local stock 2 (area = 0.97)
- ROC curve of class Carniolan honey bee (area = 1.00)
- ROC curve of class Italian honey bee (area = 0.97)
- ROC curve of class Russian honey bee (area = 1.00)
- ROC curve of class VSH Italian honey bee (area = 0.99)
- ROC curve of class Western honey bee (area = 1.00)

The focal loss

$$FL(p_t)$$

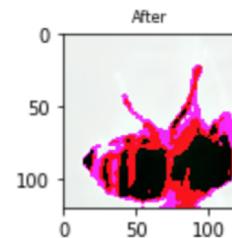
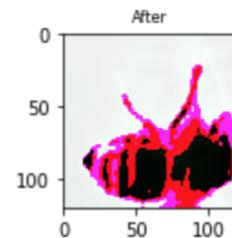
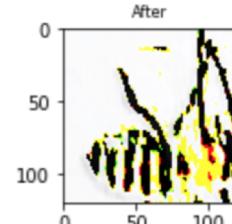
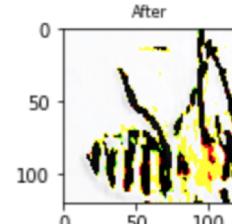
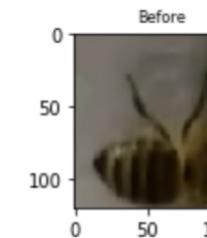
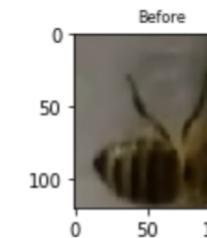
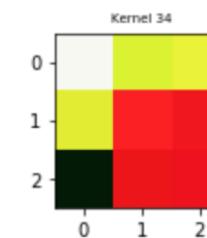
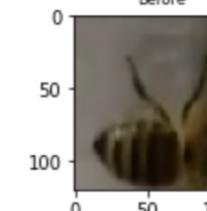
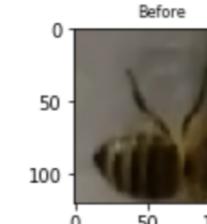
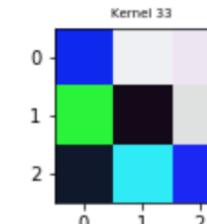
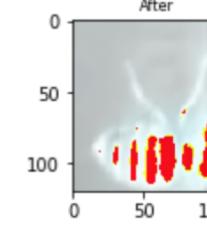
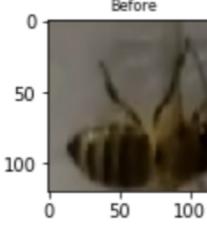
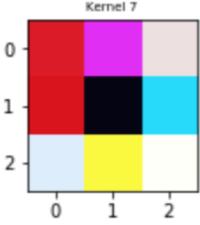
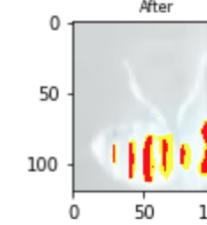
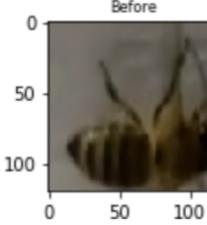
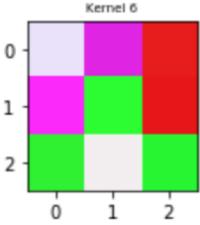
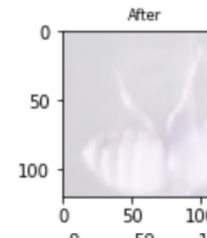
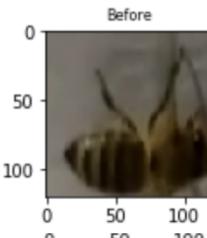
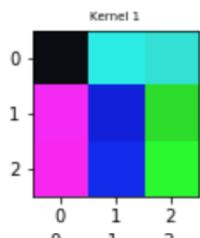
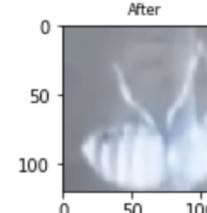
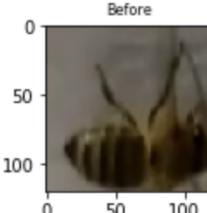
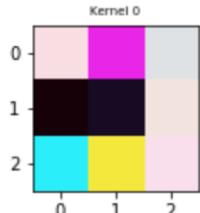
is defined as:

$$FL(p_t) = -\alpha \cdot (1 - p_t)^\gamma \log(p_t)$$

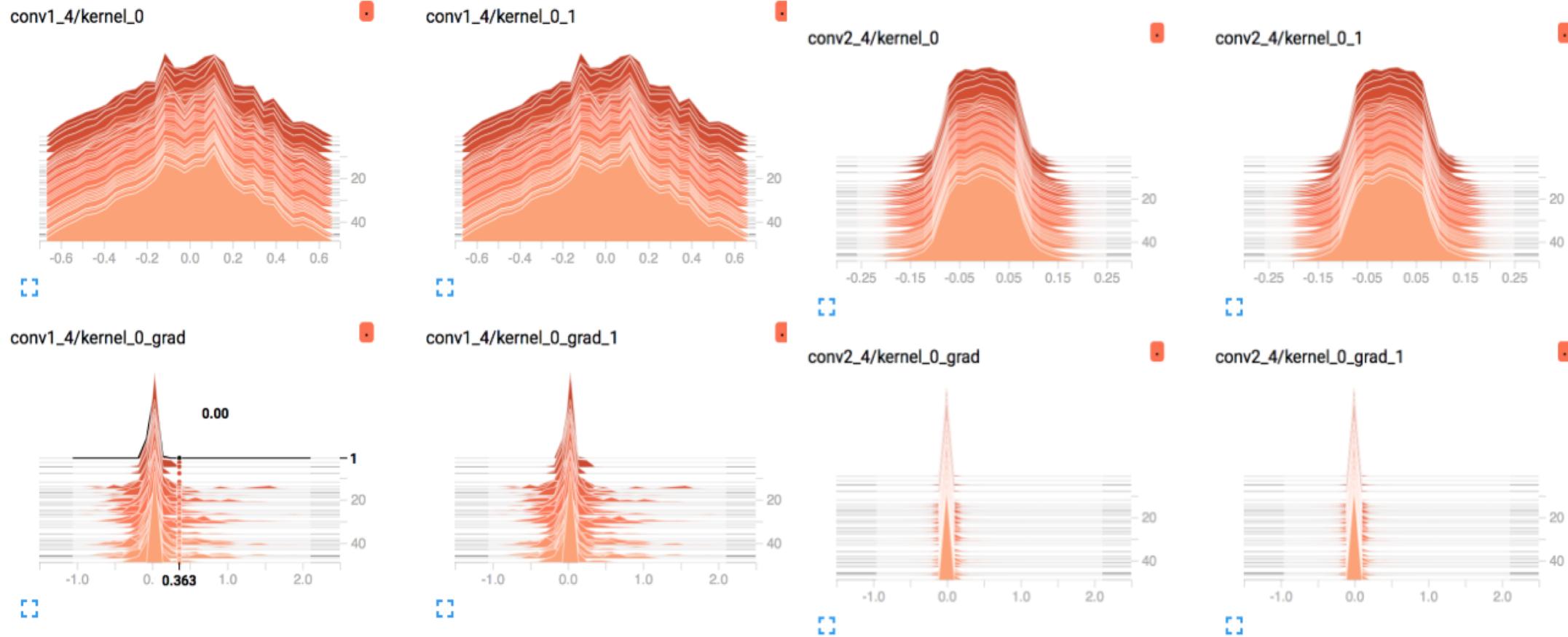
where

$$p_t = \begin{cases} p & \text{if } y = 1 \\ 1 - p & \text{otherwise,} \end{cases}$$

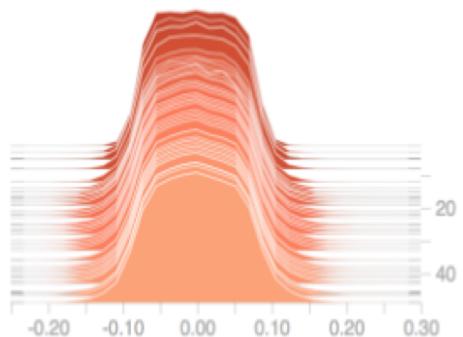
Kernel visualization



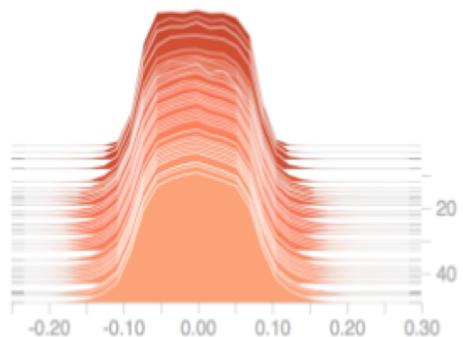
Tensorboard -- Weight



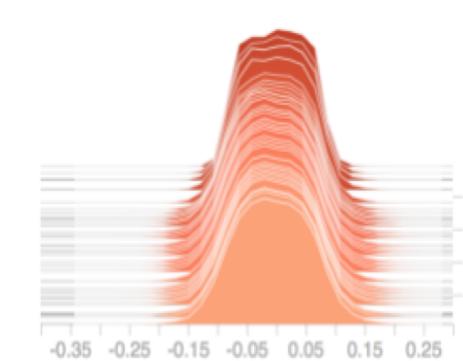
conv3/kernel_0



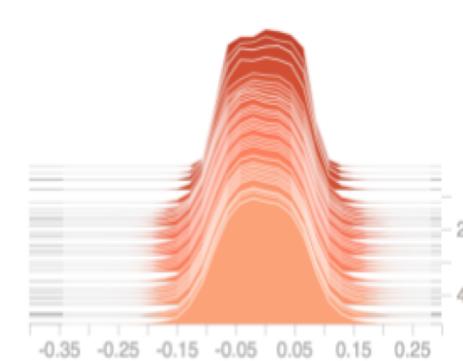
conv3/kernel_0_1



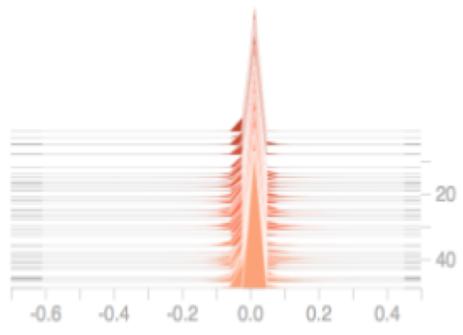
conv4/kernel_0



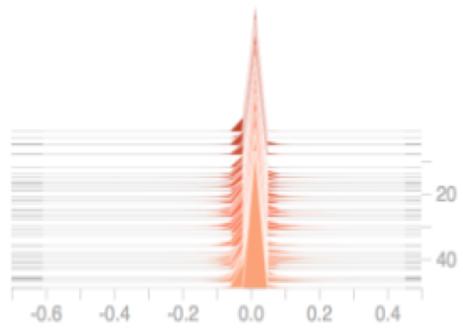
conv4/kernel_0_1



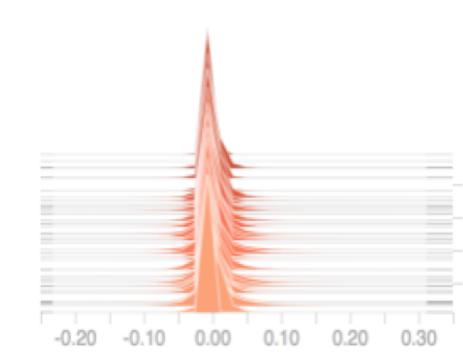
conv3/kernel_0_grad



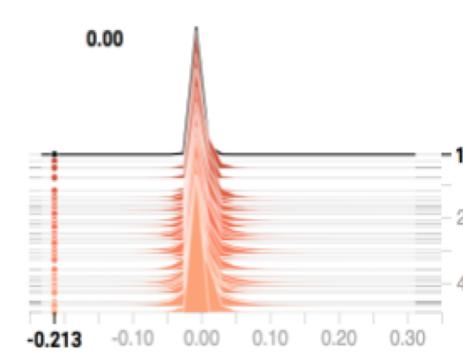
conv3/kernel_0_grad_1



conv4/kernel_0_grad



conv4/kernel_0_grad_1



Hive Health Classification - Keras

- Without Batch Normalization (Epochs = 30)|

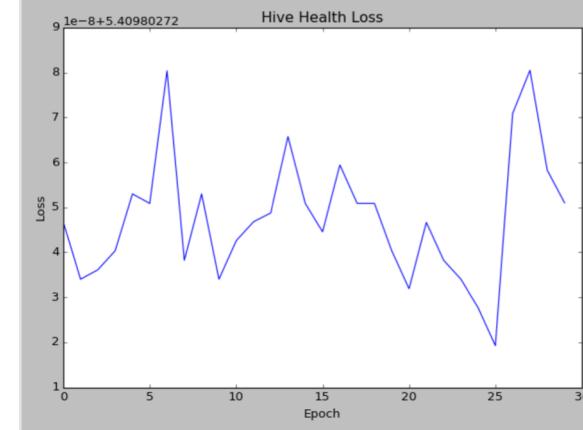
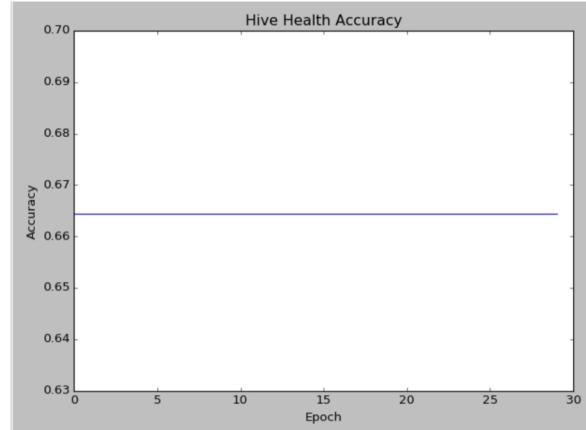
| | Training 1(Test Accuracy) | Training 2(Test Accuracy) |
|------------------------|---------------------------|---------------------------|
| Batch Size = 32 | 0.995 | 0.992 |
| Batch Size = 64 | 0.989 | 0.987 |

- With Batch Normalization (Epochs = 30)|

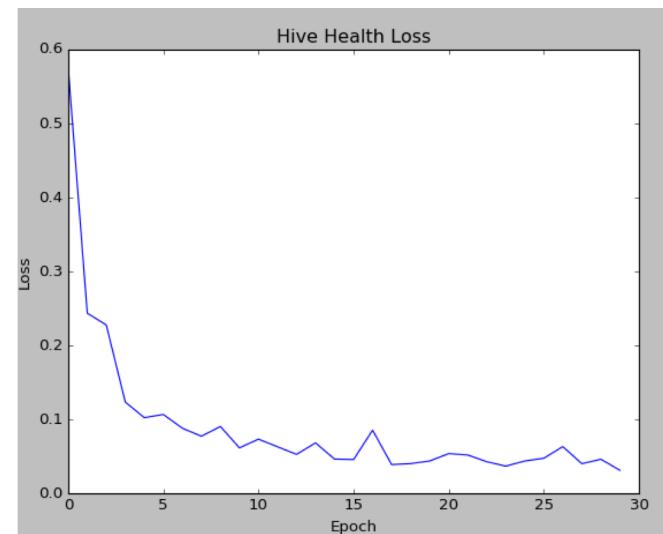
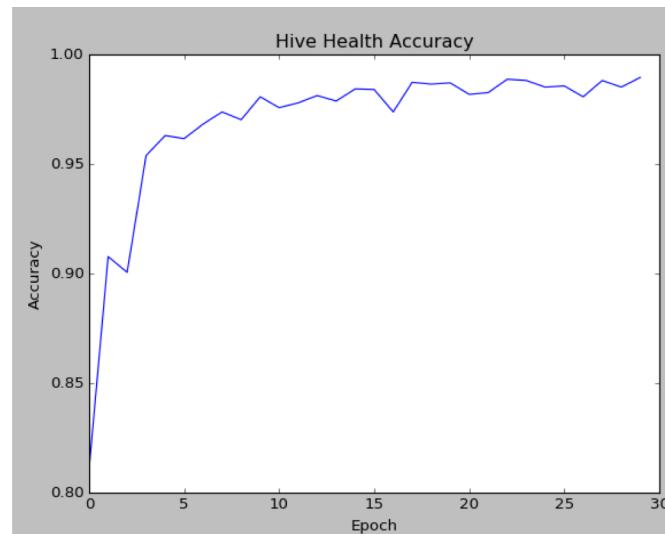
| | Training 1(Test Accuracy) | Training 2(Test Accuracy) |
|------------------------|---------------------------|---------------------------|
| Batch Size = 32 | 0.631 | 0.631 |
| Batch Size = 64 | 0.631 | 0.631 |



Hive Health Classification - Keras



| | precision | recall | f1-score | support |
|-------------|-----------|--------|----------|---------|
| healthy | 0.63 | 1.00 | 0.77 | 979 |
| unhealthy | 0.00 | 0.00 | 0.00 | 573 |
| avg / total | 0.40 | 0.63 | 0.49 | 1552 |
| | precision | recall | f1-score | support |
| healthy | 0.99 | 0.99 | 0.99 | 979 |
| unhealthy | 0.99 | 0.99 | 0.99 | 573 |
| avg / total | 0.99 | 0.99 | 0.99 | 1552 |



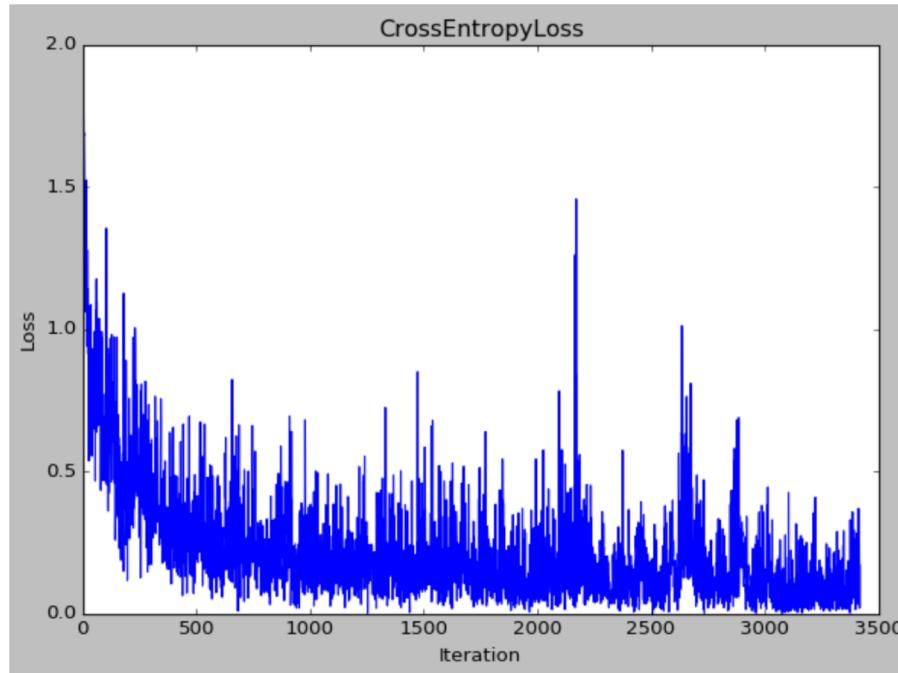
Training 2 Accuracy
and Loss
Batch Size = 32,
Epochs = 30



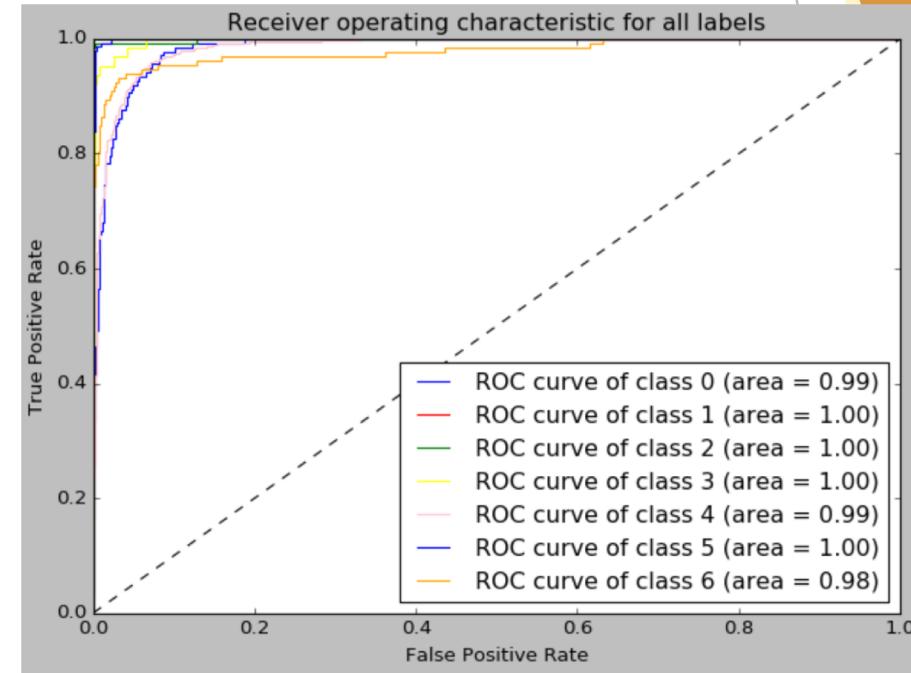
Subspecies Classification - PyTorch



Training Loss



ROC curve

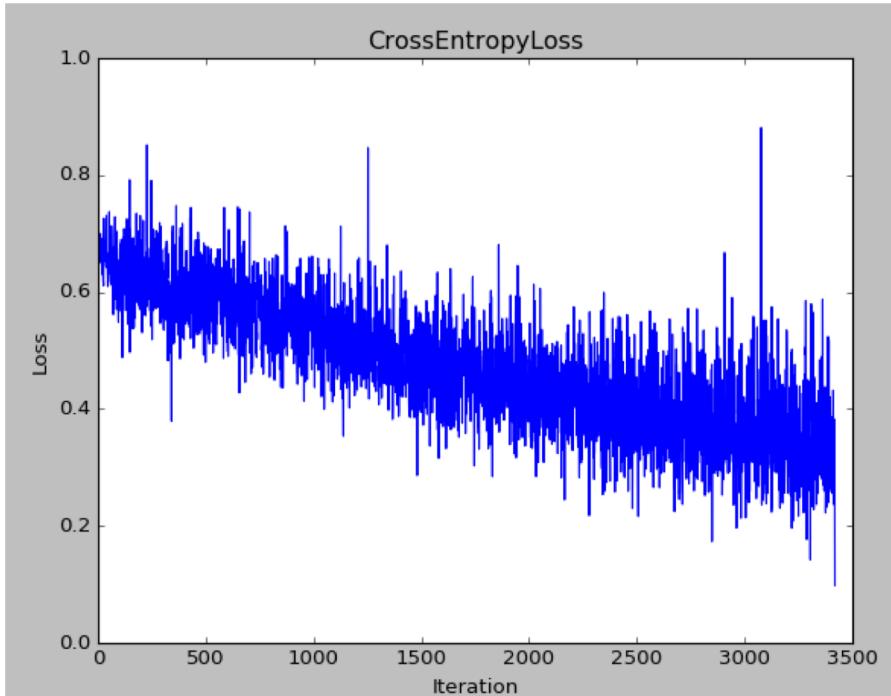


Classification Report

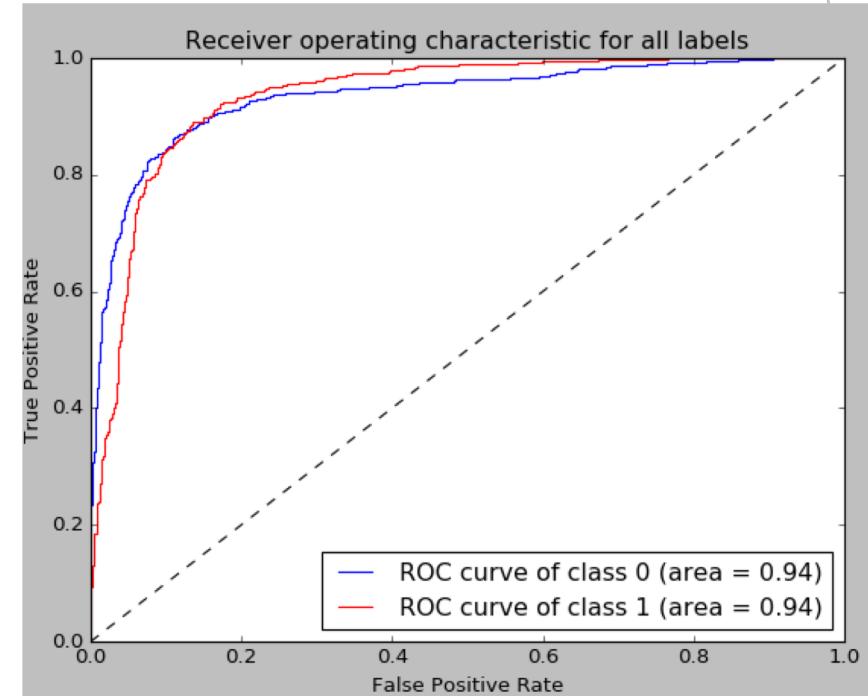
| | precision | recall | f1-score | support |
|-----------------------|-----------|--------|----------|---------|
| 1 Mixed local stock | 0.63 | 0.92 | 0.74 | 138 |
| 2 Western honey bee | 0.75 | 1.00 | 0.86 | 6 |
| Carniolan honey bee | 0.93 | 0.99 | 0.96 | 142 |
| VSH Italian honey bee | 0.86 | 0.95 | 0.90 | 64 |
| Italian honey bee | 0.97 | 0.89 | 0.93 | 914 |
| Russian honey bee | 0.89 | 0.99 | 0.94 | 155 |
| -1 | 0.97 | 0.76 | 0.85 | 133 |
| avg / total | 0.92 | 0.91 | 0.91 | 1552 |

Hive Health Classification - PyTorch

Training Loss



ROC Curve



Classification Report

```
('Computational Time:', 198.369313955307)
Test Accuracy of the model on the 1552 test images: 87 %
precision    recall    f1-score   support
```

| | precision | recall | f1-score | support |
|-------------|-----------|--------|----------|---------|
| healthy | 0.89 | 0.94 | 0.91 | 1035 |
| unhealthy | 0.85 | 0.76 | 0.80 | 517 |
| avg / total | 0.88 | 0.88 | 0.87 | 1552 |



Conclusion



- Subspecies F1 score: 0.93
- Hive Health F1 score: 0.99

- For future research, we could use more layers and change pooling methods.
- Collecting more images in the dataset to fix the imbalanced problem, we would have a better accuracy on some of the bee classes.

Thank you

